Stream Bank Erosion Contributions to Sediment Loads in Jordan Creek, Alaska: DWSM-BE Based Assessment

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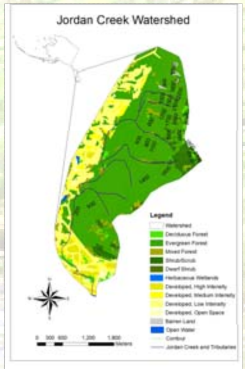

Figure 1: Jordan Creek watershed.

Abstract:

Jordan Creek, located in the city and borough of Juneau, Alaska, and draining approximately 8 square km (Figure 1) was determined to be impaired as it did not meet Alaska State Water Quality standards for sediment and dissolved oxygen. A TMDL was developed to address the sediment budget under high, moist, mid-range hydrologic conditions and improve water quality where stream bank stabilization was noted as an opportunity for future implementation. Hence, *the objective of this research is to apply the Dynamic Watershed Simulation Model with Bank Erosion (DWSM-BE) to Jordan Creek in order to simulate and quantify the natural streambank erosion percentage of the overall sediment budget deposited downstream of the Jordan Creek watershed*. The results of this research will aid in identifying regions of the stream that need critical attention for stability. The objectives were accomplished in various steps of the continuing research. The first objective was to generate all the relevant inputs and computational sequence for the DWSM model to simulate the hydrology, which is presented here. In the next step, DWSM will be used to model upland and streambed erosion, and sediment transport with a detailed stream sediment transport model STREAM. For the current study, a spring storm in the year 2010 with about 0.72 inches of total daily rainfall was used to model the single storm. Initial investigations suggested that DWSM is capable enough to model the hydrology of the Jordan Creek Watershed.

Introduction:

Overland soil erosion poses a significant concern to water quality in many watersheds across United States. Erosion and subsequent sedimentation results in water quality degradation in streams and reduced aquatic habitats. In addition to overland soil erosion, a significant quantity of in-stream sediment may result from stream bank erosion (Clark and Wynn, 2007). Several studies have shown that sediment from stream banks may account for as much as 85% of the watershed sediment yields (see Clark and Wynn, 2007 and references therein). In cold climates, such as Alaska, stream bank erosion could be accelerated due to freeze-thaw conditions during turning seasons. As a case study, the current research is conducted in Jordan Creek Watershed, located in the Southeast of Alaska and drains approximately 8 square km. In general the eastern side of the watershed is forested and mountainous (Plate 1) and the western side is urbanized (Plate 2). The Alaska Department of Environmental Conservation has determined this creek to be impaired as it does not meet Alaska State Water Quality standards for sediment and dissolved oxygen (DO). Possible sources of pollutants include stormwater derived sediment, sediments from roads, especially winter sanding, snow dumps, erosion from residential and commercial areas, and other anthropogenic induced sources.

A modeling effort is necessary in order to quantify the in-stream erosion. DWSM is a storm event, distributed, and physically based model for simulations of surface and subsurface storm water runoff, soil erosion, and entrainment and transport of sediment and agricultural chemicals in primarily agricultural watersheds during single or a series of rainfall events. STREAM is detailed stream/river sediment transport model simulating stream/river bed and bank erosion, bed armoring, and transport of graded (non-uniform) sediment in streams and rivers.

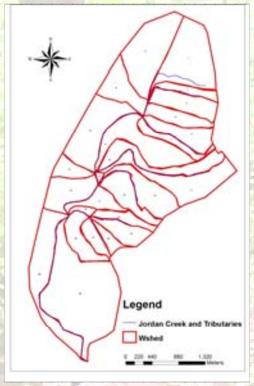

Figure 2: Delineated subwatersheds within Jordan Creek Watershed for the DWSM model.

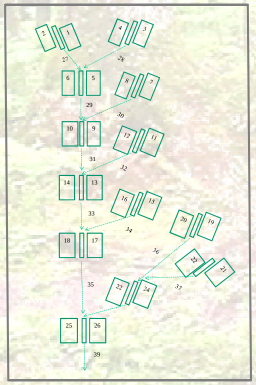

Figure 3: DWSM overland-channel representations and linkages of the Jordan Creek subwatersheds and streams.

Parameter	Description
Area	Watershed drainage area
NOV	Number of overland planes
NCH	Number of channel segments
OVA	Area of overland plane/drainage area of the channel segment
SLEN	Slope length of overland plane/length of channel segment
SLOPE	Average slope of overland plane/channel segment
CNN	Curve number of overland plane
CPER	Coefficient in the wetted perimeter versus flow area relation
EPER	Exponent in the wetted perimeter versus flow area relation

Table 1: Important parameters of DWSM and their description.

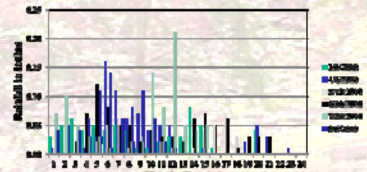

Figure 4: Single event storms that are being used for the modeling activity.

Objective:

The overall objective of the research is to apply DWSM-BE to the Jordan Creek Watershed in order to simulate and quantify hydrology and streambank erosion percentage of the overall sediment deposited downstream. The current presentation shows the work that has been performed till date, generating required dataset for hydrologic calibration of DWSM model (hydrologic calibration being the first step), computational sequence generation, and selection of the storms for the model simulation. The results achieved in the exercise will aid in achieving the primary objective.

Methodology:

1. DWSM is a distributed watershed model. The hydrologic process are simulated by dividing the watershed into 13 watersheds and subsequently into 26 overlands (Figure 2) and 13 channels. The overland planes are identified with numbers 1-26 (Figure 3) and the channel segments (27-39). These divisions took account the non-uniformities in topographic, soil, and land use characteristics, which were treated as being uniform with representative characteristics within each of the channel segment.
2. DWSM uses lumped (average) parameter values for each of the overland planes and channel segments. Important parameters that aid in hydrologic simulations (Table 1) were derived using ARCGIS and past literature.
3. Channel cross sections information was obtained from the USGS (2004) document. This information was used to estimate the parameters CPER and EPER by utilizing the equation 1.

$$P = aA^b \quad (1)$$

   Where P is the wetted perimeter, A is the flow cross sectional area, a and b are coefficient and exponent, respectively, in wetted perimeter versus flow area relationship.
4. Slope length (SLEN) was computed by area of the overland flow divided by the length of the receiving channel.
5. Average slope of the overland flow was obtained by using ARCGS and the contour lines.
6. Manning's coefficient was obtained by looking at the surface characteristics.
7. Six different single storms form March through August (Figure 4) were used for the single event simulations. The simulation used only one rain gauge station.
8. The computation sequence for the model simulation was constructed as described in Borah et. al., 2002.

Plate 1:Typical forest setting in Jordan Creek
(Source: Juneau Watershed Partnership; www.juneauwatersheds.org**)**

Plate 2:Typical urban setting in Jordan Creek
(Source: Juneau Watershed Partnership; www.juneauwatersheds.org**)**

Overland Number/ Channel Number	OVA	SLEN	SLOPE	CNN	CPER	EPER
1	180	1598	0.11	42	1	0
2	170	1509	0.04	47	1	0
3	84	959	0.09	39	1	0
4	38	434	0.09	31	1	0
5	63	3630	0.11	31	1	0
6	83	4782	0.01	48	1	0
7	42	497	0.12	31	1	0
8	79	935	0.12	31	1	0
9	120	1108	0.09	47	1	0
10	130	1200	0.01	48	1	0
11	144	917	0.14	31	1	0
12	102	650	0.22	31	1	0
13	5	361	0.01	25	1	0
14	40	2890	0.02	48	1	0
15	102	1104	0.12	25	1	0
16	83	898	0.14	25	1	0
17	48	768	0.10	47	1	0
18	92	1473	0.01	48	1	0
19	62	990	0.14	25	1	0
20	42	670	0.14	25	1	0
21	35	627	0.15	25	1	0
22	26	466	0.18	25	1	0
23	70	2737	0.20	25	1	0
24	11	430	0.08	25	1	0
25	350	1510	0.06	48	1	0
26	120	518	0.02	48	1	0
27	350	4908	0.07		10.45	0.20
28	122	3816	0.48		10.45	0.20
29	618	756	0.01		28.00	0.08
30	121	3682	0.51		10.45	0.20
31	989	4719	0.00		28.00	0.08
32	246	6839	0.27		10.45	0.20
33	1280	603	0.00		28.00	0.08
34	185	4026	0.26		10.45	0.20
35	1605	2721	0.01		28.00	0.08
36	104	2729	0.33		10.45	0.20
37	61	2430	0.29		10.45	0.20
38	246	1114	0.16		10.45	0.20
39	2321	10100	0.00		28.00	0.08

Table 2: Input parameter values for Jordan Creek overland planes and channel segments.

Results, Discussion, and Future Work:

Required dataset for DWSM modeling exercise for the Jordan Creek was successfully achieved. Dataset was generated either by utilizing USGS reports or by exploiting existing data. Out of the six single events in 2010, the event with daily total rainfall of 0.72 inches was used for preliminary model simulation. The subwatershed areas varied between 5 acres and 350 acres. Estimated average slope of the overland flows varied between 0.01 (vertical distance/horizontal distance) and 0.20. Composite curve number for each of the subwatershed varied between 48 and 25 (Table 2).

Results/inputs from this exercise will be used to achieve the next objective. The generated model output i.e., runoff will be used for hydrologic calibration of the model. After that DWSM-BE model will be developed for Jordan Creek.

References:

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